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TRANSPORTATION OF ROUGH FOREST PRODUCTS IN THE APPALACHIAN REGION

- An Appraisal of the Methods and Equipment Currently Used -

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INTRODUCTION

In 1967, an extensive field study was made of the methods and equipment currently used in transporting sawlogs and pulpwood to Appalachian mills. This investigation, carried out by the Forest Products Marketing Laboratory, Princeton, West Virginia, was made to determine the present status of such transport in this mountainous region. The immediate purpose was to obtain firsthand information on the methods and equipment used by Appalachian logging contractors in transporting roundwood products from landings to the using mills.

A second study objective was to analyze and interpret the field data and observations to determine the major problems confronting logging contractors in transporting sawlogs and pulpwood. With such background information and its subsequent analysis, planned research to alleviate problems will be conducted on a sound and realistic basis. The present paper, however, will report only the immediate findings of the field study as observed and recorded on more than 300 sawlog and pulpwood operations in the Appalachian mountain region.

STUDY METHODS

The field work was based on four major transportation inputs used by logging contractors: constructing logging truck roads, loading logs and pulpwood on trucks and rail cars, hauling to the destinations, and unloading the products. These functions filled the gap between the logging and primary manufacture phase. To perform each of them required the use of numerous methods and types of equipment. Collectively, the methods and equipment used, plus related information, composed all the variables used to describe each operation visited.

These variables were printed on key-sort cards to simplify summarizing the large amount of information collected. Ninety-four variables were listed on the cards prepared for sawlog transport, 81 for pulpwood (fig. 1). Each card, when the appropriate entries were checked and punched, represented a total picture of one contractor's transportation complex at the time he was visited.

Figure 1.--Key-sort cards used to record transportation variables: (a) sawlogs and (b) pulpwood.

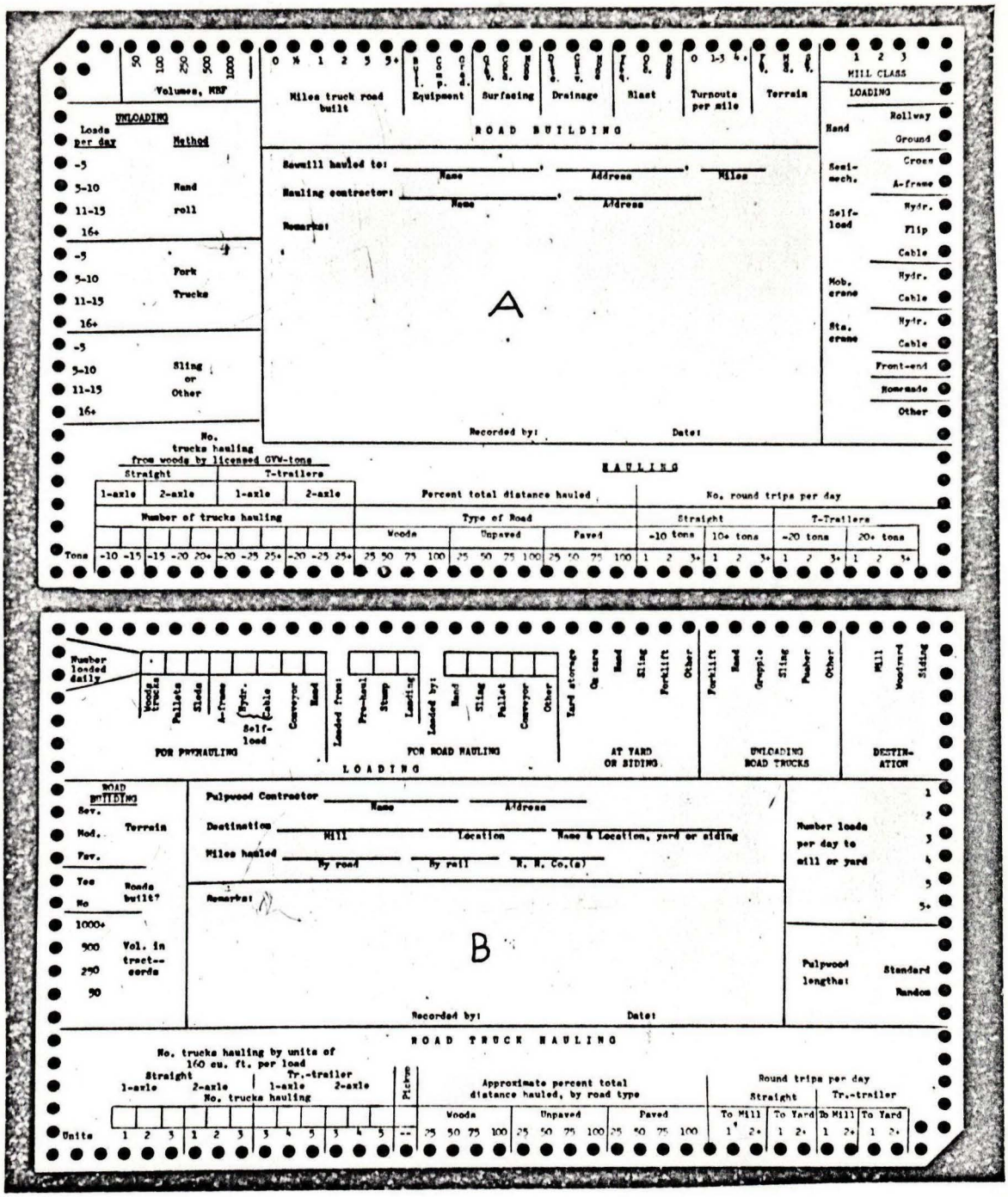

Figure 1.--Key-sort cards used to record transportation variables: (a) sawlogs and (b) pulpwood

TRANSPORTATION OF SAWLOGS

Log transport operations studied were distributed among three receiving sawmill size classes: less than 7, 7 to 15, and over 15 MBF sawn per day. In this paper, these are Class 1, 2, and 3 sawmills, respectively. Geographically, the mills and logging operations were located throughout the mountainous portions of five Appalachian states outlined in figure 2. One hundred and eighty-five operations supplying 100 sawmills were sampled, essentially on a chance basis. The sampling design was based on the ratio of total recent lumber production in these states to the number of mills in each size class as given in directory listings. Then all principal contractors supplying proportionate sample numbers of each class composed the study population, distributed as shown in table 1.

Figure 2.--Hatched area indicates region included in the study.

Table 1.--Number of contractors per sawmill size class per state

State	Sawmill size class			Total contractors per state
	1 - small Up to 7MBF daily	2 - medium 7 to 15MBF daily	3 - large Over 15MBF daily	
West Virginia	15	27	29	71
Virginia	13	5	27	45
North Carolina	5	13	18	36
Tennessee	9	9	0	18
Kentucky	4	4	7	15
Total contractors per mill class	46	58	81	185
No. sawmills by size class	44	32	24	100

RESULTS

In capsule form, a few highlights disclosed by the study follow:

1. Twenty-eight percent of the contractors logging for small mills, 16 percent of those hauling to medium mills, and 17 percent who supplied large mills, did not build truck roads.
2. Seventy-six percent of the contractors hauling to small mills, 66 percent to medium mills, and 61 percent to large mills, built 2 miles or less of truck roads. However, for roads 5 miles or longer, these proportions were 12, 13, and 34 percent respectively.
3. The most frequently used truck type--51 percent--hauling to small mills was the straight 1-axle truck licensed for 20,000 to 30,000 pounds, GVW. At large mills, only 16 percent of this type delivered logs; the most frequent was the tandem axle truck licensed for 40,000 pounds plus, GVW.
4. Less than 5 percent of all trucks hauling to all mill classes were tractor-trailers, principally delivering to the largest mills.
5. Sixty percent of the contractors hauling to small mills, 50 percent to medium mills, and about 15 percent to the large mills hand-loaded their trucks.
6. For all mills combined, the most frequent loading method was by mobile crane with cable and tongs, used by 39 percent of all contractors. But second most frequent was by hand--about 37 percent--either from rollways or from the ground.

7. Average 1-way distances, landings to mills, all truck types combined were: small mills - 11.3 miles; medium mills - 17.8 miles; large mills - 27.2 miles. Average distance, all mills combined was 20.1 miles.

8. At small and medium size mills, more than 80 percent of the contractors rolled logs off trucks by hand, at large mills more than 80 percent unloaded with mechanized equipment.

The detailed statistics and accompanying comments follow in the logical sequence of: building truck roads, loading logs, road hauling from landings to mills, and unloading at mills.

ROAD BUILDING

Not all logging operations required road building. Some tracts were within presumed economic skidding distance of public roads; others utilized private roads already built such as those serving coal mines and gas wells, commonplace in parts of the region. In our study, 19.5 percent of all logging contractors dispensed with road building, but differing among mill size class as follows:

Mill Class	Total Operations	Contractors not Building Roads
	No.	Percent
1	46	28.2
2	58	15.5
3	81	17.3
Combined	185	19.5

Apparently, loggers supplying small mills operate in stands requiring less road building. One reason may be that these contractors tended to log small volume tracts. For example, the most frequent boundary size estimate was under 100 MBF. In contrast, the commonest tract size supplying the largest mill class was over 1,000 MBF.

Most contractors, however, did build and use logging truck roads of various lengths. Tables 2, 3, and 4 give the relationship between these contractors, size of tract logged, and sawmill size class.

Table 2.--Percent of contractors who build roads by volume in tract, and by separate and combined mill classes

Mill class	Volume in tract (MBF)						
	Less than 50	51-100	101-250	251-500	501-1,000	More than 1,000	Mill class totals
1	12	25	16	22	12	12	100
2	13	11	21	17	19	19	100
3	7	8	17	14	10	44	100
Average combined mills	10	13	18	17	14	28	100

Table 3.--Percent of contractors who build roads, by length classes built for separate and combined mill classes

Length class	Mill class			Combined mill classes
	1	2	3	
--Miles built--	---------- Percent ----------			----Percent---
Up to 1/2	48	30	15	28
1/2 - 1	19	15	14	15
1 - 2	9	21	32	23
2 - 5	12	21	5	12
+5	12	13	34	22
Total all classes	100	100	100	100

Table 4.--Percent of all contractors who build roads, by volume in tract and miles of road built, combined mill classes

Volume in tract (MBF)	Miles of road built					Combined mileage classes
	Up to 1/2	1/2-1	1-2	2-5	5+	
50	21	19	6	0	0	10
100	21	24	12	6	0	13
250	18	24	25	12	10	18
500	16	24	16	40	0	17
1000	18	0	12	24	13	14
+1000	5	10	28	18	77	28
Total all tract sizes	100	100	100	100	100	100

Table 2 shows a trend toward increasing size of tract as mill size increases. Also, using the combined mill data, the smallest volume tracts were logged by the fewest operators; nearly three times as many operators logged tracts over 1,000 MBF.

Table 3 compares average miles of road by length classes, built by contractors hauling to each mill class. Nearly half the contractors logging for small mills built the shortest 1/2 mile road class; for medium mills, about one-third of contractors built roads 1/2 mile or shorter. Large mills, however, showed the opposite relationship: about one-third of the contractors built roads 1 to 2 miles long and another one-third built roads over 5 miles long.

There was an expected correlation of tract volumes and length of road built: large columes generally justified more road building, small tracts the opposite. For example, 60 percent of all contractors building not more than 1/2 mile of road logged 250 MBF or less; but 82 percent building from 2 to 5 miles of road logged tracts of 500 MBF or more (table 4).

How were truck roads built? We had assumed most construction would be by bulldozer only; this was substantiated because all the sampled contractors used crawler tractors with blade for basic road construction. A few, logging for medium and large sawmills, reported occasional use of air compressors for rock work and of road graders for maintaining roads. But the usual road building equipment, as expected, was bulldozers only, frequently the same ones used in bunching and skidding (table 5).

Table 5.--Frequency of road building equipment use by operators serving each mill class

Equipment used	Mill class		
	1	2	3
	--------- Percent of operators --------		
Bulldozer only	100	96	75
Bulldozer & compressor	0	4	7
Bulldozer, compressor, & grader	0	0	18

Other road building variables we assessed were the frequencies of road surfacing, drainage facilities, use of blasting, and turnouts constructed. Table 6 shows these frequencies based on all contractors for each mill class.

Table 6.--Frequencies of road surfacing, drainage facilities, blasting and turnout construction by all contractors hauling to each mill class

Description of operation	Mill class		
	1	2	3
	--- Percent of contractors ---		
Surfacing:			
Gravel	3	6	30
Corduroy	0	0	0
Both	3	0	0
None	94	94	70
Drainage:			
Ditching	12	16	11
Culverts	15	12	9
Both	15	17	28
None	58	55	52
Blasting:			
Frequently	9	2	21
Occasionally	6	12	7
None	85	86	72
Turnouts per Mile:			
4+	0	4	3
1 - 4	33	33	39
None	67	63	58

From the response indicated in table 5, road building is apparently carried on with relatively little refinement. Slightly more than half the contractors did not perform any additional work beyond bulldozing an access route for log trucks. Otherwise, more attention was directed to drainage than to surfacing, blasting, or turnouts. Drainage is an important consideration in the study region because of steep slopes, erosible soils, and heavy local downpours at times.

An assessment was made of local terrain characteristics on each road building job because of their probable affect on the alignment and profile of these roads. Most of the contractors felt the best description was "moderate", with the remainder about equally divided between "favorable" and "severe" terrain (table 7).[1/]

LOADING SAWLOGS

Trucks were loaded at landings either by hand, by semi-mechanical means, or with mechanized equipment. Among these systems, a total of 12 methods were used. The 6 commonest techniques are shown in table 8; the rest were used so infrequently they are grouped as miscellaneous.

1/ The author has recently completed an associated study of Appalachian logging road configuration. Preliminary findings indicate the majority of these roads actually have "favorable" overall alignments and profiles.

Table 7.--Percent of operators building roads by terrain characteristics, per mill class

Terrain characteristic 1/	Mill class			Combined classes
	1	2	3	
Favorable	27	27	21	24
Moderate	40	61	57	54
Severe	33	12	22	22

1/ Favorable: Grades estimated up to 10 percent.

Moderate: Grades estimated up to 20 percent.

Severe: Grades estimated from 0 to more than 20 percent.

Table 8.--Frequencies of loading techniques by loading method and mill class

Mill class	Loading Method						
	Hand		Mechanical				
	Rollway	Ground	Mobile crane cable	Sta. crane cable	Front end	Homemade	Misc.[1/]
	BASIS I: Percentage of contractors by mill class[2/]						
1	41	19	16	4	12	4	4
2	24	26	35	1	3	6	5
3	10	5	55	1	9	11	9
1+2+3	22	15	39	2	7	7	8
	BASIS II: Percent of truck round trips per day, by mill class[3/]						
1	48	15	17	4	9	5	2
2	21	18	50	2	3	4	2
3	5	4	72	1	6	6	6
1+2+3	19	11	54	2	6	5	3

1/ Miscellaneous includes: Cross-haul, A-frame, and self-loading trucks. No hydraulic-powered cranes were observed.

2/ Number of logging contractors were as follows: Mill class 1 - 46, Mill class 2 - 58, and Mill class 3 - 81 for a total of 185 contractors.

3/ Number of truck round trips per day were as follows: Mills class 1 - 151, Mill class 2 - 258, and Mill class 3 - 368 for a total of 777.

The fact that hand-loading of trucks is still commonplace stands out as a significant finding. Six out of 10 contractors supplying the small Class 1 mills loaded their trucks from the ground or off a rollway by hand. And, half the contractors hauling to Class 2 mills sawing up to 15 MBF daily used this method. Even for large mill loading, it was the second most frequent method although far less common than mechanized systems. But for combined mills and contractors, nearly as many loaded by hand as by mobile cable crane--37 and 39 percent, respectively.

In mechanical loading, the mobile crane with winch, cable, and tongs was used by more contractors than any other equipment, especially for medium and large mill loadings. Thirty-five and 55 percent, respectively, loaded with this useful equipment. For operators serving these two larger mill classes, use of mobile crane was about twice as frequent as all other powered devices combined.

We found no hydraulically operated crane, stationary or mobile although some are used in the region. However, front-end loaders on which the lifting forks are hydraulically activated were fairly common but used much less than mobile cable type cranes, or hand-loading.

Other methods that found only limited use were the semi-mechanical cross-hauling or loading with A-frames, any type of self-loading truck and a very few miscellaneous devices.

Table 8 also gives use-frequencies of loading equipment and methods but based on numbers of daily round trips by all trucks in each mill classification. While the percentage values differ somewhat from those given above, the relative use-frequencies are about the same.

Three basic truck types were used in all loading and hauling operations observed: straight 1-axle, straight 2-axle, or tandems, and tractor-trailers. Table 9 shows the total number of trucks by type recorded in the study and the proportional distribution of loading methods among these types.

Table 9.--Frequencies of loading techniques by basic truck type and mill class

Truck type and numbers used		Loading Methods						
		Hand		Mechanical				
		Rollway	Ground	Mobile crane cable	Sta. crane cable	Front-end	Homemade	Misc.
(No.)	(Type)	(Percent of trucks loaded)						
				MILL CLASS - 1				
54	Straight 1-axle	44	26	11	2	9	4	4
21	Straight 2-axle	29	0	33	13	21	4	0
1	Tractor-trailer	0	0	0	0	100[1/]	0	0
				MILL CLASS - 2				
62	Straight 1-axle	34	30	26	2	6	2	0
40	Straight 2-axle	5	0	80	3	0	10	2
1	Tractor-trailer	0	0	0	0	0	0	100[2/]
				MILL CLASS - 3				
31	Straight 1-axle	23	16	48	0	7	3	3
125	Straight 2-axle	3	0	64	5	13	10	5
9	Tractor-trailer	0	0	100	0	0	0	0
				MILL CLASS 1 + 2 + 3				
147	Straight 1-axle	35	26	25	1	7	3	3
186	Straight 2-axle	6	0	64	5	11	10	4
11	Tractor-trailer	0	0	82	0	0	9	9
344								

1/ One tractor-trailer loaded by method indicated

2/ One tractor-trailer loaded by A-frame

Table 9 shows that hand-loading methods predominated on the single-axle straight trucks. With their smaller log volumes consisting of fewer logs and lower load heights, manual loading on these trucks was apparently more feasible than on the larger trucks. Average log volumes loaded per truck were: single axle straight: 1,200 board feet; tandem axle straight: 2,000 board feet; and tractor-trailers: 3,000 board feet.

Table 10 gives proportions of the daily volume of sawlogs loaded and hauled on each truck type, by the loading method used, for each mill class. The percentage values were computed from the estimated average volume per truck multiplied by the total daily round trips by all trucks in this class. The data are interpreted as in these examples: 29 percent of the daily volume hauled to Class 1 mills was hand-loaded from a rollway onto straight 1-axle trucks; and 59 percent of the daily volume delivered to Class 3 mills was loaded by a mobile cable crane onto straight 2-axle trucks.

A glance at this table should pinpoint the two salient findings. First, the largest single percent category of truck/method/mill combination is obviously the tandem truck type, loaded by mobile cable crane, hauling to mill Class 3. It is also the largest category for combined mill classes. More than 40 percent of all logs delivered to Appalachian sawmills are loaded and transported this way.

The second feature, also prominent in tables 8 and 9, is: the heavy reliance on hand-loading of logs destined for Class 1 and 2 sawmills. In

Table 10.--Proportion of daily volume loaded by each loading method per truck type, for each mill class[1/]

Truck types	Loading method						
	Hand		Mechanical				
	Rollway	Ground	Mobile crane--cable	Sta. crane--cable	Front-end	Home-made	Misc.
	----- Percent of volume loaded for each destination ------						
			MILL CLASS - 1				
Straight 1-axle	29	6	10	3	6	3	)
Straight 2-axle	19	6	6	2	4	2	)*
Tractor-trailer	1	1	*	0	*	0	)
			MILL CLASS - 2				
Straight 1-axle	11	10	21	1	1	2	)
Straight 2-axle	12	10	23	1	1	2	)*
Tractor-trailer	*	*	1	0	0	0	)
			MILL CLASS - 3				
Straight 1-axle	*	*	9	*	1	1	)
Straight 2-axle	3	2	59	2	7	6	)*
Tractor-trailer	0	0	6	*	1	1	)
			MILL CLASS 1 + 2 + 3				
Straight 1-axle	7	4	12	1	2	1	)
Straight 2-axle	7	5	43	2	5	4	)2
Tractor-trailer	*	*	4	*	1	*	)

1/ Estimated log volume per truck hauled:
Straight 1-axle: 1,200 board feet
Straight 2-axle: 2,000 board feet
Tractor-trailer: 3,000 board feet

* Negligible

fact, 62 percent of volume destined for Class 1 mills and 43 percent of volume destined for Class 2 mills are currently hand-loaded. For Class 3 mills, however, only about 5 percent of all log volumes supplied to Appalachian mills are still hand-loaded.

Most other loading methods occurred so infrequently they are excluded from the table. These were: semi-mechanical by cross-haul or A-frame; all self-loading trucks; and a small miscellaneous group. Only about 2 percent of the log volume in the study were loaded by these miscellaneous methods.

ROAD HAULING

The actual transport of sawlogs between landings and mills is, we feel, the principal major function of the four we studied. Road hauling involved a number of related measurements and descriptive data to accurately delineate its status. These include: number of trucks used by type, weight, and axle classification; the distribution of fleet sizes among the contractors; number of round trips per day between landings and mills; 1-way mileage; proportion of road types used; and various combinations of these items. Our findings, again by each and combined sawmill size classes, follow.

The previous section tabulated a partial breakdown of the numbers of trucks hauling to each mill class--a total of 344 trucks operated by the 185 contractors visited. Table 11 gives the proportionate distribution of all trucks used, by type, number of rear axles, and gross vehicle weight (GVW) in pounds based on this truck population.

The table clearly shows a strong relation between truck type and mill size class: as mill size increases, there is a definite trend away from the most frequent 1-axle truck hauling to Class 1 mills. Seventy-two percent of the trucks servicing these mills were of this type; 61 percent supplied Class 2 mills, and only 18 percent delivered logs to Class 3 mills. Conversely, the use of tandem axle trucks by mill class 1, 2, and 3 was 27, 39, and 76 percent, respectively.

Eleven trucks, 3 percent of the total, were tractor-trailers and nearly all hauled to large mills. We felt this was a significant finding, that tractor-trailers with their relatively large volume capacity, were so seldom used. There were two principal reasons voiced by a number of contractors: first cost, and second, the rough terrain. Most contractors strongly preferred the shorter wheelbase straight trucks; on the average logging roads with their many curves plus the usual need for turning around at landings, maneuverability of trucks was an exceedingly important requirement that long tractor-trailers lacked. We know of a few contractors who piggy-backed empty trailers back to the woods landings. Even these needed above-average woods roads for the reassembled and loaded tractor-trailer to negotiate on the trip out. We noted that most tractor-trailers were used principally on the longest hauls--50 to 100 miles.

Table 11.--Population of log trucks sampled by type, gross vehicle weight, number of rear axles and mill size destination

Mill class Destination	Truck types							
	Straight					Tractor - trailers		
	1-axle		2-axle			2-axle[1/]		
	GVW ranges		GVW ranges			GVW ranges		
	-20,000	20 - 30,000	-30,000	30 - 40,000	40,000+	-40,000	40 - 50,000	50,000+
	Percent							
1	21	51	7	16	4	0	1	0
2	16	45	2	9	28	0	-1	0
3	2	16	1	31	44	0	0	6
1+2+3	10	32	3	21	31	0	-1	3

[1/] No single axle tractor-trailers were found in our sample.

Size of Truck Fleet

Another study finding was the relative frequencies of truck fleet size used by all contractors. The most frequently operated "fleet" was but a single truck, reported by 43 percent of the logging contractors sampled. This finding held true in all mill size classes although the percentage frequencies were in inverse ratio to increasing mill size class, ranging from 48 to 40 percent of the contractors (table 12).

Somewhat lesser proportions of contractors operated 2-truck fleets. Together, contractors operating either one or two trucks represented from 73 to 89 percent of all contractors sampled in the study. The largest fleet, six trucks, was used by only one contractor hauling to a large mill.

Round Trips per Day

As a rule, average round trips per day logically were inversely proportional to the haul distance between landings and mills. Other variables presumably contributed to the number of trips made--road and weather conditions, terrain, driver experience, truck condition, availability of a log supply--all could affect the number of trips. We considered only two factors in the evaluation: distance traveled, and three types of road surfacing--paved and unpaved public roads, and woods roads, essentially the logging roads discussed earlier.

Table 12.--Frequencies of truck fleet size used by all contractors per mill class, and combined classes

Sawmill class	Fleet size - all truck types combined					
	1	2	3	4	5	6
	Percent					
1	48	41	9	2	0	0
2	45	36	16	3	0	0
3	40	33	16	7	2	1
1+2+3	43	36	14	5	1	1

Each contractor provided us an estimate of his present 1-way haul distance, landing to mill. These were classified into 6 mileage classes, from less than 5 to 40 miles or more. Related information was also obtained on the round trips per day per truck and an estimate of the proportions of road types over the 1-way distance hauled. All these data were summarized as shown in table 13.

Several pertinent facts emerge from this table:

1. Average 1-way mileage was positively correlated with increasing daily mill capacity.
2. Approximately 75 percent of all log hauling was on paved roads. The remainder was divided about equally between unpaved and woods roads.
3. No trucks supplying Class 1 mills hauled logs more than 36 miles.
4. Log hauling to Class 2 and 3 mills ranged from less than 5 to 40 or more miles. (The maximum we found was 100 miles).
5. Round trips per truck per day was negatively correlated to 1-way distance ranges, but not perfectly.
6. Average round trips per truck day was greatest for Class 2 mill deliveries, least for Class 1 but differences were not substantial.
7. Average daily mileage per truck was:

Mill Class 1:	46 miles	
Mill Class 2:	86 miles	Combined classes: 86 miles
Mill Class 3:	116 miles	

Table 13.--Average number of round trips per day by distance traveled and proportions of road types, all truck types combined by separate and combined mill classes

Mill class	1-way distance class	R/T/day per truck	Average 1-way distance	Proportion 1-way mileage by road surface type		
				Woods	Unpaved	Paved
	(miles)	(number)	(miles)	(percent)		
1	-5	2.3	3.8	24	22	54
	5-10	2.2	6.7	12	12	76
	11-15	2.3	13.5	11	22	67
	16-25	1.9	19.7	6	13	81
	26-40	1.1	33.0	4	6	90
	40+	0.0	0.0	0	0	0
Average		2.0	11.3	9	12	79
2	-5	3.8	3.4	29	24	47
	5-10	2.7	8.2	19	17	64
	11-15	2.7	13.4	14	16	70
	16-25	2.1	18.9	12	17	71
	26-40	1.9	29.3	12	3	85
	40+	2.0	48.6	4	7	89
Average		2.5	17.8	13	12	75
3	-5	3.8	3.0	22	44	33
	5-10	2.5	7.8	13	13	74
	11-15	2.7	12.6	12	24	65
	16-25	2.5	21.5	17	13	70
	26-40	2.0	31.6	7	13	80
	40+	1.3	63.2	9	12	79
Average		2.2	27.2	11	13	76
Combined mill classes	-5	2.9	3.6	25	25	50
	5-10	2.5	7.5	15	14	71
	11-15	2.6	13.1	13	19	68
	16-25	2.3	20.4	13	14	73
	26-40	1.8	31.2	8	9	83
	40+	1.4	60.7	8	11	81
Average		2.3	20.1	11	13	76

Table 13a.--Proportion of total log truck mileage by distance category and destination

Destination	Mileage class	R/T/day per truck	Ave. 1-way dist. per mileage class	Weighted distance	Proportion of total truck haul
		(number)	(miles)	(miles)	(percent)
Mill class 1	-5	53	3.8	201.4	12.8
	5-10	51	6.7	341.7	21.8
	11-15	7	13.5	94.5	6.0
	16-25	29	19.7	571.3	36.3
	26-40	11	33.0	363.0	23.1
	40+	0	0.0	0.0	0
Total		151	76.7	1571.9	100.0
Mill class 2	-5	45	3.4	153.0	3.8
	5-10	62	8.2	508.4	12.0
	11-15	54	13.4	723.6	18.5
	16-25	51	18.9	963.9	24.5
	26-40	30	29.3	879.0	21.8
	40+	16	48.6	777.6	19.4
Total		258	121.8	4005.5	100.0
Mill class 3	-5	19	3.0	57.0	0.6
	5-10	56	7.8	436.8	5.0
	11-15	39	12.6	491.4	5.6
	16-25	150	21.5	3225.0	36.8
	26-40	64	31.6	2022.4	23.1
	40+	40	63.2	2528.0	28.9
Total		368	139.7	8760.6	100.0
Combined mill classes	-5	117	3.6	421.2	2.9
	5-10	169	7.5	1267.5	8.8
	11-15	100	13.1	1310.0	9.1
	16-25	230	20.4	4692.0	32.7
	26-40	105	31.2	3276.0	22.8
	40+	56	60.7	3399.2	23.7
Total		777	136.5	14365.9	100.0

8. Logically, as 1-way distance increased, the proportion of woods road travel usually decreased: about 25 percent of the 1-way distances under 5 miles was on woods roads; but on hauls of 40 miles or more, only 9 percent or less were on logging roads. However, the percent of travel on woods roads was about the same for all mill classes served.

Table 13 gives road hauling data for all truck types combined, while table 13a shows the proportionate truck mileage by distance categories. Table 14 shows average 1-way distance over all road surfaces by separate truck types, vehicle weights, and axle arrangement.

There is a general upward trend in 1-way distances traveled as both truck capacity and mill size increase. It is reasonable to assume that contractors trucking longer distances would prefer larger volumes per load, hence tandem trucks and tractor-trailers generally showed the longer average hauls.

Table 14.--Average 1-way hauling distances by each truck type, number of axles, and gross vehicle weight in pounds

Mill class	Truck types								
	Straight					Tractor-trailer[1]			Combined trucks
	1-axle		2-axle			2-axle			
	-20,000	20 - 30,000	-30,000[2]	30 - 40,000	40,000+	-40,000	40 - 50,000	50,000+	
	Miles								
1	5.8	12.5	10.0	16.4	17.0	0.0	30.0	0.0	11.3
2	14.0	17.8	18.0	20.0	19.5	0.0	16.0	0.0	17.8
3	11.0	20.9	10.0	37.5	21.5	0.0	0.0	57.3	27.2
Averages: By weight classes & axles	9.6	16.5	11.3	30.9	20.8	0.0	23.0	57.3	20.1
By No. axles	14.7			24.0			43.8		
By truck type	19.6						43.8		
All trucks combined	20.1								

1/ Data source limited to 11 trucks.

2/ Data source limited to 8 trucks.

Unloading at Mill

Thus far, we have shown by tables and discussions how Appalachian logging contractors build roads, load their trucks, and haul logs to the mill yards, using various equipment and methods and their combinations. The transportation phase ends with the final operation--unloading at the mill--as described below.

Unloading was the least complex and most rapid of any main activity. Only two methods were used: logs remaining on the truck, after removing binder chains and stakes, were rolled off by hand; or they were mechanically unloaded by powered equipment, principally forklift trucks or front-end loaders.

Size class of the sawmills where logs were delivered was a barometer of methods and equipment used to unload, as in the other activities. Table 15 shows the methods frequencies based on the number of contractors using the methods given.

By far, most contractors delivering to small mills rolled logs off by hand with cant hooks. Nine contractors out of 10 used this method and, as previously shown (table 8), 6 out of 10 loaded the same way.

At Class 2 mills, manual unloading was also the most frequent method, used by 71 percent of the contractors delivering there. Loading at the landing also showed a similar pattern.

Table 15.--Frequency of methods used to unload trucks, by proportion of contractors delivering to separate and combined mill classes

Mill class	Hand roll	Forklift	Sling or other
	---------- Percent ---------		
1	89	11	0
2	71	26	3
3	18	82	0
1+2+3	53	46	1

The large Class 3 mills showed a complete reversal of the contractors' unloading techniques, also noted in loading practices: less than 20 percent followed manual procedures because front-end loaders or similar mechanized equipment were used at all but one large mill visited. Those contractors who did unload by hand gave reasons such as: equipment was busy on other yard work at the time--moving lumber, conveying logs to the mill, unloading other trucks--or was out of commission.

The unloading category "sling or other" was almost non-existent. One contractor hauled logs on modified dump trucks, another bulldozed the logs off with a crawler tractor. All other operations in the study used manual or fork truck unloading only.

Frequencies of unloading techniques, based on total truckloads per day by basic truck types per mill class, are given in table 16.

The total and subtotal values in this table, of course, approximate those in table 15. Table 16, however, measures the relative frequency of unloading methods based on total daily loads (round trips) made by each truck type listed. Using truckloads as the base, the dependency on hand unloading at all mills is somewhat more pronounced than operator-based percentages.

Table 16.--Frequencies of unloading techniques by total loads per day and basic truck type, for separate and combined mill classes

Mill class	Truck type	Unloading methods			
		Manual	Mechanical		
			Fork truck	Other	Truck total
		Percent			
1	Straight 1-axle	71	5	0	76
	Straight 2-axle	20	3	0	23
	Tractor-trailers	0	1	0	- 1
	Sub-total	91	9	0	
2	Straight 1-axle	44	10	5	59
	Straight 2-axle	28	11	1	40
	Tractor-trailers	*	1	0	1
	Sub-total	72	22	6	
3	Straight 1-axle	7	12	0	19
	Straight 2-axle	13	64	0	77
	Tractor-trailers	0	4	0	4
	Sub-total	20	80	0	
1+2+3	Straight 1-axle	32	10	2	44
	Straight 2-axle	19	35	*	54
	Tractor-trailers	*	2	0	2
	Total	51	47	2	

* Negligible

Are the frequencies of loading by one basic technique similar to those of an equivalent unloading technique? That is, do contractors who as a class load by hand usually unload manually? Do those who load mechanically unload the same way? Table 17 presents these relationships which are quite different between mill classes. The majority of contractors--59 percent--hauling logs to Class 1 mills used both hand-loading and unloading. Only 10 percent mechanized both phases. At the opposite extreme, mechanical equipment for both operations was used by 75 percent of the contractors supplying large mills. Only 7 percent combined manual loading and unloading and the mixed categories are small also.

Table 17.--Frequencies of contractors who load and unload trucks by: (1) manual techniques; (2) mechanized techniques; and (3) mixed techniques, by separate and combined mill classes

Mill class	Unloading techniques	Loading techniques	
		Manual	Mechanized
		------ Percent ------	
1	Manual	59	31
	Mechanized	0	10
2	Manual	37	32
	Mechanized	14	17
3	Manual	7	11
	Mechanized	7	75
1+2+3	Manual	30	23
	Mechanized	8	39

SUMMARY

The transportation of sawlogs is clearly no "assembly line" proposition. Although all contractors are engaged in the one business of moving logs from woods to mill, in our study no two were cast in the same methods-techniques-equipment mold. However, they are engaged in a difficult activity the very nature of which does not lend itself to conformance to a set pattern; thus, the 185 operations on which this report is based all differed to some degree.

However, we can synthesize these operations into a single theoretical transportation system by combining the most frequently used variables disclosed in the study. The resulting operation would be as follows: we assume our composite logging contractor is hauling to a large Class 3 sawmill; this class had the largest number of contractors per mill regularly delivering logs.

The contractor built over 5 miles of road to a tract containing at least a million, probably several million, board feet of merchantable timber. The road was built with a bulldozer. The chances were that no blasting was required nor a road grader used for drainage. Also, the chances that he would provide some gravel surfacing were only 1-in-3 with ditching or culverts rather sparsely used, if at all. There was less than a 50 percent probability he would provide any turnouts on the 5 miles plus of road which was built in moderate terrain.

At the landing, his one tandem-axle straight truck, licensed for at least 40,000 pounds, GVW, would most probably be loaded with a mobile cable-type crane. The landing was about 27 miles from the mill. He would, over a period of time, average 2.2 round trips per day over a route which was three-fourths paved, the rest about equally divided between unpaved and woods roads.

At the mill, unloading would almost certainly be by forklift truck to complete one cycle of our composite transportation system. Of course, in a more detailed description, many other characteristics would be listed but these were beyond the scope of our study.

TRANSPORTATION OF PULPWOOD

Pulpwood producers in the Appalachian region operate in the same difficult terrain as do logging contractors. And, of course, they also build roads, load the rough product, haul to destinations, and unload with equipment and techniques similar to that described for sawlog transport.

However, with respect to transportation, the significant differences are these: pulpwood is a relatively low-value commodity; and it is a small-dimension product, far more subject to manual handling than are logs. These two characteristics undoubtedly have some bearing on what we found in the general field of pulpwood transportation.

We visited 137 pulpwood producers who supplied 8 paper mills in Maryland, Virginia, North Carolina, and Tennessee. The men we contacted represented actual pulpwood loggers; they were not dealers or brokers. These independent crews were small, from 2 to 5 men, commonly 3.

About half the sampled producers trucked wood directly to the 8 mills, the remainder to 22 outlying woodyards and rail sidings from which the wood was transported to its destination, mostly by rail, otherwise on inland waterways. The distribution by numbers of producers hauling to each destination was as follows:

Hauling destination	State						Totals
	Md.	Va.	N. C.	Tenn.	Ky.	W. Va.	
Mills (8)	13	17	19	21	0	0	70
Woodyards & sidings (22)	0	13	13	21	8	12	67
Totals	13	30	32	42	8	12	137
Percent	9	22	23	31	6	9	100

The number of producers composing our sample was proportionately distributed according to the pulping capacity of the 8 mills, by state. Sources of pulpwood were immaterial other than all truck transportation was in the Appalachian region. Thus, all 8 mills were dependent in whole or part on Appalachian species, nearly all hardwoods.

ROAD BUILDING

Less than half--46 percent--of the sampled pulpwood producers reported building woods roads on their current operations. In distinct contrast, nearly twice as many sawlog contractors built roads, as shown previously. Part of this difference may be traced to the substantial variance in unit values of pulpwood versus sawlogs; many pulpwood producers are likely operating on a narrow profit margin so must minimize their road investment. Another reason is that pulpwood size stands tend to be less remote from public roads than quality sawlog timber which is becoming increasingly scarce. Also, pulpwood harvested after a sawlog cutting can utilize the original road network for transportation. And, producers may not build roads if the terrain is favorable for stump loading.

Road building was not considered a major function in pulpwood transport, so we did not collect detailed information on this aspect. It was related only to the estimated volume of pulpwood on the current cutting, by destination, and to the truck types used by the producers (tables 18 and 19).

Table 18.--Proportion of producers who do or do not build roads by volume in tract and by each destination

Destination	Number	Estimated volume in tract (cords)					
		Unknown	50	250	500	1000+	Total
		Percent					
Mill	Building	3	6	6	8	33	56
	Not building	3	19	7	8	7	44
Woodyard & siding	Building	1	9	8	10	8	36
	Not building	1	21	18	12	12	64
Both destinations	Building	2	8	7	9	21	46
	Not building	2	20	12	10	9	54

Table 19.--Association between load volumes, truck type, and proportion of pulpwood producers who build roads

Truck types	Load volumes, units of 160 cu. ft.					Total
	1	2	3	4	5	
	Percent					
Straight						
1-axle	0	17	56	-	-	73
2-axle	0	2	22	-	-	24
Tractor-trailer						
1-axle	-	-	0	0	3	3
Pickups, etc.	No roads built					-
Totals	0	19	78	0	3	100

Note that road building frequency in table 18 showed a substantial difference in comparing producers' destinations: 56 percent hauling to mills built roads, only 36 percent who trucked to yards. The difference was even more pronounced on large tracts of 1,000 cords or more. Of the producers hauling direct to mills from these tracts, 85 percent constructed woods roads while only 38 percent of those bound for woodyards did so.

For all producers hauling to both destinations, nearly as many built roads in the 1,000+ cord tracts as in the combined smaller tracts. Of those not building roads, the majority were cutting in the smaller tracts of 50 cords or so.

LOADING AND UNLOADING

Loading and unloading procedures recorded in this study are shown on the pulpwood key-sort card in figure 1. One of the loading functions is prehauling--a possible alternative to road building, ground skidding, or loading at the stump. It consists of loading 5-foot wood at its source on pallets, sleds, or non-highway trucks which are skidded or driven to a central landing. There the road trucks are loaded by one of the listed methods, then driven either to a pulpmill or to a woodyard. In the latter case, one more loading function occurred--transferring the wood to barges or pulpwood rack cars mechanically, or rarely, by hand. If cars were in short supply, the wood was bundled and stored on the ground, actually an unloading phase. However, only for wood trucked directly to a mill did we record unloading methods. The only data we obtained on transportation from woodyards were the methods of loading cars. In practice, cars were unloaded at the mills the same way as were trucks--nearly always by crane and cable sling.

In table 20, we show the proportionate use of equipment and techniques for prehauling by the 15 producers in this category.

Table 20.--Proportions of producers who prehaul by frequencies of equipment used and methods of loading prehaulers

Prehauler	Method of loading prehauler	Producers		Prehaul equipment	
		No.	Percent	No.	Percent
Woods trucks	A-frame	0	0	0	0
	Hydraulic	0	0	0	0
	Manual	7	46	25	36
Pallets	A-frame	1	7	9	13
	Hydraulic	1	7	6	9
	Manual	6	40	29	42
Total producers and equipment	A-frame	1	7	9	13
	Hydraulic	1	7	6	9
	Manual	13	86	54	78
Totals		15	100	69	100

Prehauling was not a common practice with Appalachian pulpwood producers: only 15 of those visited--11 percent--prehauled to road truck landings. Of those who did prehaul, 54 percent loaded pallets while the remainder used woods trucks or flat bed trailers without pallets. Loading of prehaul equipment was predominately by hand--in fact, all woods trucks and 66 percent of the pallets were manually loaded (table 21).

Seventy-eight percent of all producers loaded their road trucks at landings; 11 percent from prehaulers, 67 percent from wood skidded tree-length and bucked at the landings. Where the terrain permitted, producers loaded directly at the stump; 22 percent of our sampled operators thus eliminated prehauling or skidding by this loading procedure (table 21).

In table 22, we show data similar to table 21 but based on numbers of truckloads per day by loading methods and origin of pulpwood.

The percentage values in table 22 were computed from a total of 225 truckloads per day hauling 603 units of 5-foot pulpwood. Thus, the average volume per load was 2.68 units. One hundred and sixty-six trucks of all types were used so there was an average of 1.35 loads or round trips per day.

Table 21.--Proportions of producers loading road trucks by percent of daily volume loaded,[1] method of loading, and origin of pulpwood

Origin	Loading method									
	Hand		Sling		Pallet		Other[2]		Total	
	Pdcr.	Vol.	Pdcr.	Vol.	Pdcr.	Vol.	Pdcr.	Vol.	Pdcr.	Vol.
	Percent									
At landing: From prehaul	6	4	0	0	5	6	0	0	11	10
Tree-length skidding	40	35	17	20	0	0	10	16	67	71
Loaded at stump:	19	16	1	1	0	0	2	2	22	19
Totals	65	55	18	21	5	6	12	18	100	100

[1] In units of 160 cubic feet.

[2] Principally tractor-mounted front-end loaders.

Table 22.--Proportions of daily truckloads of pulpwood by percent of daily volume loaded,[1] method of loading, and origin of pulpwood

Origin	Loading method									
	Hand		Sling		Pallet		Other[2]		Total	
	Trks.	Vol.	Trks.	Vol.	Trks.	Vol.	Trks.	Vol.	Trks.	Vol.
	Percent									
At landings:										
Prehaul	4	4	0	0	6	6	0	0	10	10
Tree-length skidding	37	35	19	20	0	0	14	16	70	71
Loaded at stump:	17	16	<1	<1	0	0	2	2	20	19
Total	58	55	20	21	6	6	16	18	100	100

[1] Based on units of 160 cubic feet.

[2] Principally tractor-mounted, front-end loaders.

Pulpwood Handling at Woodyards and Sidings

Of our 137 producers sampled, 67 hauled only to a woodyard or rail siding.[2/] At these points, most truckloads were transferred directly to pulpwood rail cars or barges. When these facilities were temporarily lacking or mills overstocked, the wood was placed in ground storage and usually bundled with steel strapping. The proportions of loads transferred to cars and barges or to ground storage were as follows, by the handling methods used:

	Method of Transfer		
Transferred to:	Sling	Grapple	Both
	---------- Percent ---------		
Cars or barges	74	5	79
Ground storage	21	0	21

We found no woodyard operations moving wood manually or with forklift trucks and only one yard using a crane and grapple.

In our study, only 8 truckloads per day delivered by 6 producers, were hauled to rail sidings and all were loaded by hand directly on cars. No mechanized loading equipment was available at the three sidings visited,

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[2/] We made no special effort to arrive at the nearly 50-50 distribution of producers delivering to yards or to mills. Thus, we assume such distribution represents about the actual proportions of all producers currently delivering to either point, at least for the pulpmills involved.

hence the 100 percent hand-loading. In contrast, every woodyard did have mechanized equipment and was, in addition, designed specifically for receiving and shipping only pulpwood in relatively large volumes.

Pulpwood Trucked to Mill

Seventy producers trucked directly to the mills either because of a relatively short haul or because pulpwood price differentials compensated for the greater cost of increased trucking distances, up to some estimated break-even mileage.

Ninety-two percent of all truckloads arriving at the mills were unloaded by crane and wire rope sling, 8 percent by grapple used at only one mill. At none of the mills was any other method used.

ROAD HAULING

Truck Type

Pulpwood producers used a much higher proportion of single axle straight trucks than all other types combined, particularly when hauling to woodyards (table 23). For mill deliveries, twice as many "bobtail" trucks were used as tandems and tractor-trailers together; but for wood delivered to yards and sidings, 7 times as many single axle trucks were used as combined tandems and pickups. No tractor-trailers were observed at the latter destinations. Average volumes shown in table 23 for each truck type are based on estimates only. They were obtained by observing loaded trucks or by conversion to units from sample loads weighed at mills and yards.

Table 23.--Percentage of pulpwood trucks hauling and average volume hauled by load destination

-- Destination and Volume per Truck --

Truck types	Mill	Average volume per truck	Woodyard	Average volume per truck	Siding	Average volume per truck	Average Combined destination	Average Volume per truck
	Percent	Units	Percent	Units	Percent	Units	Percent	Units
Straight:								
1-axle	67	2.8	87	2.4	100	2.8	77	2.6
2-axle	30	3.0	10	3.0	0	0.0	20	3.0
Tractor-trailer:								
1-axle	3	5.0	0	0.0	0	0.0	2	5.0
Pickup	0	0.0	3	1.0	0	0.0	1	1.0

Values based on:

127	1-axle straight trucks	- 77 percent
34	2-axle straight trucks	- 20 percent
3	tractor-trailers	- 2 percent
2	pickups	- 1 percent
166	Trucks	

Size of Truck Fleet

Eighty-two percent of all pulpwood producers operated a single truck which, from table 23, was a 1-axle straight truck, 2 times out of 3. Only 16 percent used 2 trucks, the remainder 3 or 4 truck fleets. These percentages differed slightly between destinations: 1-truck producers hauling to woodyards and sidings occurred more frequently than those delivering at the mill (table 24).

Round Trips per Day and Distance Hauled

Average 1-way distance for all producers hauling to all destinations was 24.4 miles, about 4 miles further than for all sawlog contractors. But comparative numbers of daily round trips fell considerably short: 1.4 by the pulpwood producers and 2.2 by the loggers. These and related pulpwood statistics are shown in table 25, the pulpwood counterpart of table 13. Table 25a gives the proportionate truck mileage by distance categories. Note that nearly half the total daily truck mileage to the mills was generated in the 40+ miles distance class. In sharp contrast, less than 3 percent of all truck movements to woodyards and sidings fell in this distance category.

A major feature of the road hauling function was the average 1-way mileage difference between the destinations shown. Producers trucking to the mills traveled just about twice the distance as those hauling to yards and sidings--approximately 33 and 16 miles, respectively. We

Table 24.--Proportions of producers by size of truck fleet hauling to each destination

Destination	Fleet Size			
	1	2	3	4
	Percent			
Mill	77	19	3	1
Woodyard	85	15	0	0
Siding	100	0	0	0
All	82	16	1	1

Table 25.--Relationship between truck round trips/day, average 1-way distance, and proportion of haul by different road surface types for each load destination category

(Pulpwood)

Destination	1-way distance class	R/t/day per truck	Average 1-way distance	Proportions of 1-way mileage by road surface types		
				Woods	Unpaved	Paved
	-- Miles --	-- No. --	-- Miles --	---- Percent -----		
Pulpmill	-5	0.0	0.0	0	0	0
	5-10	1.6	6.2	13	29	58
	11-15	1.4	13.5	4	16	80
	16-25	1.3	20.3	3	6	91
	26-40	1.2	32.6	5	4	91
	40+	1.2	53.7	2	6	92
Averages		1.3	32.6	3	6	91
Woodyard	-5	2.0	3.7	0	45	55
	5-10	1.8	8.0	13	19	69
	11-15	1.7	13.3	5	12	83
	16-25	1.5	19.4	3	13	83
	26-40	1.1	30.0	3	3	93
	40+	1.0	48.0	0	6	94
Averages		1.6	15.8	5	12	84
Rail sidings	-5	0.0	0.0	0	0	0
	5-10	1.0	8.5	6	41	53
	11-15	0.0	0.0	0	0	0
	16-25	1.5	20.0	3	10	87
	26-40+	0.0	0.0	0	0	0
Averages		1.3	16.2	3	15	81
All destinations	-5	2.0	3.7	0	45	55
	5-10	1.7	7.6	12	23	65
	11-15	1.6	13.4	5	13	82
	16-25	1.4	19.8	3	10	87
	26-40	1.2	32.3	4	4	92
	40+	1.2	53.5	2	6	93
Averages		1.4	24.4	4	8	89

Table 25a.--Proportion of total pulp truck mileage by distance category and destination

Destination	Mileage class	Total R/T/day, all trucks	Ave. 1-way dist. per mileage class	Weighted distance	Proportion of total truck haul
		(Number)	(Miles)	(Miles)	(Percent)
Mill	-5	0	0.0	0.0	0.0
	5-10	8	6.2	49.6	1.3
	11-15	12	13.5	162.0	4.3
	16-25	18	20.3	365.4	9.9
	26-40	46	32.6	1499.6	38.9
	40+	31	53.7	1664.7	44.6
Total		115		3741.3	100.0
Woodyard and Sidings	-5	6	3.7	22.2	1.2
	5-10	29	8.0	232.0	13.0
	11-15	35	13.3	465.5	26.0
	16-25	40	19.5	780.0	43.7
	26-40	8	30.0	240.0	13.4
	40+	1	48.0	48.0	2.7
Total		119		1787.8	100.0
All Destinations	-5	6	3.7	22.2	0.4
	5-10	37	7.6	281.2	5.1
	11-15	47	13.4	629.8	11.4
	16-25	58	19.8	1148.4	20.7
	26-40	54	32.3	1744.2	31.6
	40+	32	53.5	1712.0	30.8
Total		234		5537.8	100.0

assume this is partly due to the more favorable price paid for trucked wood at the mill since no rail haul cost is incurred. However, many woodyards are purposely located fairly close to extensive pulp producing areas; collectively they represent a convenient market for local producers too distant from the receiving mill for profitable trucking. Conversely, it is most probable that pulpwood sources nearer to mills have already been exploited thus forcing producers further afield.

SUMMARY AND CONCLUSION

Transporting rough forest products in the Appalachian region is achieved by a heterogenous combination of methods, types of equipment, and working conditions of weather and terrain. These mixes ranged from simple to relatively complex in the four transport phases of road-building, loading, road hauling and unloading. We found no really standard system of performing any of these functions. Logs were loaded on trucks by over half a dozen different methods with hand-loading still commonplace. Logging contractors operated anywhere from 1 to 6 trucks which themselves represented many different combinations of truck types, gross vehicle weight, and axle arrangement. Distance hauled varied from 1 to more than 100 miles over terrain ranging from favorable to severe. One out of 5 logging contractors built no truck roads while the remainder constructed from less than half to more than 5 miles of road usually to rather low standards. Variations in pulpwood transport followed about the same pattern but tended toward somewhat less complexity and variety.

While a great deal of diversification was disclosed in sawlog and pulpwood transportation, this study has presented the occurrence frequencies of the many variables employed. The study also shows that the more elaborate, and perhaps more efficient, sawlog transport systems characterize the large Appalachian sawmills, not the small or even medium class mills.

One of our indirect findings was this: despite the wide variety of methods and equipment use observed and reported, nearly all logging and pulpwood operators had one characteristic in common--the fact they are really in two businesses. One is harvesting, the other transportation, each dependent on the other. However, we have speculated on whether merging these two functions into a single enterprise, now the common practice, is the most efficient arrangement. If a contractor's sole function was transportation only, would he load trucks by hand? Would he want to run expensive logging trucks over rough, low-standard logging roads; would he be content with hauling small loads for long distances? We would think not, yet these are some of the common practices in the Appalachian logging industry today.